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July 22, 2005

SUBMITTED ELECTRONICALLY

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20005

Re: **Shared Use of the 2496-2500 MHz Band between Industrial, Scientific and Medical ("ISM") Devices and Broadband Radio Service ("BRS"); IB Docket No. 02-364 and ET Docket No. 00-258; NOTICE OF ORAL EX PARTE COMMUNICATION of the Association of Home Appliance Manufacturers ("AHAM")**

Dear Ms. Dortch:

Pursuant to the provisions of Section 1.1206 of the rules of the Federal Communications Commission ("FCC" or "Commission"), AHAM submits this notification of *ex parte* communication between AHAM staff and members of the FCC staff. In particular, on July 21, 2005, David Calabrese and Larry Wethje of AHAM, Paul Schomburg of Panasonic, Tom Miller and John Osepchuk of Maytag, Wayne Myrick of Sharp and the undersigned counsel met with the following members of the FCC's staff: Patrick Forster (Office of Engineering and Technology ("OET")); Ron Chase, (OET); Geraldine Matisse (OET); Howard Griboff (International Bureau ("IB")); Paul Locke (IB); Shameeka Hunt (OET); Jamison Prime (OET) and Lisa Cacciatore (IB).

The attached presentation was circulated at the meeting and discussed. AHAM also referenced the attached draft document produced by the International Special Committee on Radio Interference ("CISPR"), which demonstrates, among other things, that the nature of emissions from microwave ovens will not permit limitation of the use of part of the ISM band (*i.e.*, the segment from 2496-2500 MHz) without the re-design of those devices.

In addition to the points contained in the attached material, AHAM made two other arguments orally. First, it noted that in recent studies, it was determined that the average United States household uses its microwave oven nine (9) minutes each day. Therefore, to the extent that the so-called BRS Parties are able to demonstrate (as they have not to date) that there is harmful interference between BRS and ISM, there is no indication that BRS devices would typically be operating at the same time as microwave ovens would be in use. Any harmful interference by ISM devices would, at worst, be episodic.[1/] Finally, AHAM noted that the BRS Parties continue to irresponsibly mischaracterize AHAM's position before the FCC. The BRS Parties assert that AHAM has not disagreed with the BRS Parties' position that microwave ovens will cause harmful interference to BRS operations. In fact, on multiple occasions, AHAM emphatically stated that it disagrees with the BRS Parties' statement that ISM devices pose a threat to BRS stations.[2/] The BRS Parties' continued distortion of the record is troubling.

If there are questions regarding the foregoing or the attached, please contact the undersigned.

Cordially yours,

/s/

Russell H. Fox

Attachments

cc (each electronically and with attachments):
Patrick Forster
Ron Chase
Geraldine Matisse
Howard Griboff
Paul Locke
Shameeka Hunt
Jamison Prime
Lisa Cacciatore

1/ Moreover, as AHAM also pointed out, the BRS Parties have not examined whether the use of techniques, such as physical separation of BRS transmitters away from microwave ovens, would mitigate the effects of any demonstrated harmful interference.

2/ *See* the *ex parte* statements submitted by AHAM on January 21, 2005 and March 30, 2005.

Association of Home Appliance Manufacturers

Meeting with FCC Staff

July 21, 2005

FCC Docket Nos. 02-364 and 00-258

AHAM
association of home
appliance manufacturers

Background

- **AHAM is a trade association representing the major, portable and floor care appliance industry.**
  - Representing 163 companies.
  - Major Appliance Division represents manufacturers of microwave ovens

Background – *FCC Proceeding*

- In this proceeding, the FCC added a terrestrial fixed and mobile service allocation to the band 2495-2500 MHz.
- The FCC's action is designed to accommodate Broadband Radio Service ("BRS") licensees in the band 2496-2500 MHz relocated from the band 2150-2160/2162 MHz.
- The new BRS home is part of the band 2400-2500 MHz, which is dedicated on a world-wide basis for industrial, scientific and medical ("ISM") devices.

Petitions for Reconsideration

- **Finding themselves in the ISM bands, parties representing BRS interests now wish to change the rules governing ISM devices to accommodate a perceived – *but not demonstrated* – risk of interference.**
- **BRS Parties ask that ISM devices in the band marketed after December 31, 2006, comply with the radiated emission limits of 15.209 of the rules (i.e. 500 microvolts/meter, measured at 3 meters).**
- **Today, ISM devices are not required to comply with radiated emission limits but, consistent with international practice, must only comply with out-of-band limits.**

The BRS Parties Have Provided no Support for their Position

- **Although they claim that they will be subject to harmful interference, the BRS Parties provide no evidence to support that claim.**
  - They also claim, with no support, that microwave ovens are "spectrally inefficient."
- **The BRS parties attempt to shift the burden of proof to ISM manufacturers to demonstrate the negative – that there will be no interference to BRS operations.**
  - However, any challenge to the FCC's rules imposes the burden on the petitioner to demonstrate that the FCC's decision should be changed.

Adoption of the BRS Parties' Position would be Contrary to Worldwide Standards

- **The 2400-2500 MHz band is dedicated on a worldwide basis for ISM operations.**
- **The radiofrequency characteristics of ISM devices are measured by out-of-band emissions, not in-band emissions, like Part 15.**
- **Therefore, requiring microwave oven manufacturers to meet Part 15, in-band emission limits would subject them to a different standard than anywhere else in the world.**

The In-Band Limits Proposed are Untenable

- **If the FCC imposed in-band limits, microwave ovens could not meet those limits, now or in the future, without manufacturers making significant expenditures and product redesign that might not be acceptable to consumers.**
- **The FDA currently imposes an in-band limit on microwave ovens that is <u>4 million</u> times less stringent than the BRS parties propose.**

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Adoption of the BRS Parties' Position would be Contrary to the Fundamental Nature of the ISM Bands

- The FCC has repeatedly stated that devices in the ISM bands are not required to protect licensed services, so long as they observe applicable out-of-band limits.
- The BRS parties demonstrate no reason why the FCC should depart from this long-held position.
- If there is a problem with operating BRS devices in the ISM band, the answer is not to change the long accepted ground rules for ISM operations.

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Consequences of Different U.S. Regulatory Treatment

- Because microwave ovens are designed for international use, the enormous costs to redesign them for the U.S. market could not be spread on a world-wide basis.
- Manufacturing devices for the U.S. market only might drive the cost of microwave ovens beyond what consumers would accept.

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The BRS Parties Ignore the Embedded Base of Microwave Ovens

- There are approximately 115 million microwave ovens in use in the United States today.
- It is anticipated that most of these devices will continue to be in use for 9-14 years.
- The change sought by the BRS parties will do nothing to change the impact that these devices will have on their operations.

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The BRS Parties Ignore Other Alternatives

- **Even if there is interference to BRS operations (which the BRS parties fail to demonstrate), the BRS parties make no attempt to address how they can resolve that interference.**
- **BRS product design, consumer notification and other mechanisms must be explored before disrupting a worldwide regulatory scheme and consumer accepted products.**

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The Public Interest Dictates Rejection of the Petitions for Reconsideration

- **There are 115 million microwave ovens in use in the U.S.**
- **There are virtually no BRS devices in use.**
- **The BRS parties' anti-consumer request would require – without any technical justification – a fundamental change to the cost and/or performance characteristics of a well accepted product for a speculative product and service.**

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CISPR/B/333/CD

COMMITTEE DRAFT (CD)

IEC/TC or SC: CISPR/B	Project number CISPR 11 A2 f4 Ed. 4.0	
Title of TC/SC: Interference relating to industrial, scientific and medical (ISM) radio-frequency equipment, to other (heavy) industrial equipment, to overhead power lines, to high voltage equipment and to electric traction	Date of circulation **2004-06-18**	Closing date for comments **2004-09-24**
Also of interest to the following committees	Supersedes document CISPR/B/329/MCR	

Functions concerned:
☐ Safety ☒ EMC ☐ Environment ☐ Quality assurance

Secretary: K. Okamoto, (Japan)	THIS DOCUMENT IS STILL UNDER STUDY AND SUBJECT TO CHANGE. IT SHOULD NOT BE USED FOR REFERENCE PURPOSES. RECIPIENTS OF THIS DOCUMENT ARE INVITED TO SUBMIT, WITH THEIR COMMENTS, NOTIFICATION OF ANY RELEVANT PATENT RIGHTS OF WHICH THEY ARE AWARE AND TO PROVIDE SUPPORTING DOCUMENTATION.

Title:
CISPR 11, Load conditions for a microwave cooking appliance

(Titre) :

Introductory note

WG1 received a proposal from the Korean NC regarding clarification of load conditions for microwave cooking appliances. During the WG1 meeting in Wilmington, US, it was agreed that a CD would be prepared with two options for NC's to indicate their preferred option.

Attention, the amendment proposed in this CD and in particular references to pages relate to the text of the current valid edition of CISPR Publication 11, namely: CISPR Publication 11 Edition 4 (2003-03).

* Page 53

6.5.4 Microwave cooking appliances

Replace the second sentence of the first paragraph by the following three ones:

Option 1:

The water container shall be a cylindrical container of borosilicate glass of an external diameter of approximately 190 mm and a height of approximately 90 mm.

or

Option 2:

The water container shall be a cylindrical container of borosilicate glass of an external diameter of 190 mm +/- 10 mm and a height of 90 mm +/- 3 mm.

ANNEX

Subject: Load conditions for a microwave cooking appliance

The fundamental frequency of the microwave oven as an ISM (Industrial, Scientific and Medical) equipment is 2,450 MHz. Radiated emission disturbance measurements for the microwave oven are required to be performed the frequency range 30 MHz to 1 GHz and 1 GHz to 18 GHz according to the regulation of CISPR 11. And, these spectrums are related to the electron motion in magnetron and impedance of waveguide system and oven cavity. Furthermore, The electron motion and impedance can be varied with the load amount, kind, shape, load container type, and etc. RF power output for microwave oven has been also depended on these properties. An analytical and experimental analysis of the relative function of magnetron and the spectrum comparison for some different types of water container is presented. In this study, it is illustrated that the mechanism of impedance change due to load is resulted in spectrum change, and he specified water load container is proposed to clarify the indefinite description on CISPR 11 for the operating condition.

Introduction

On CISPR 11 Edition 3.1 (1999), "Industrial scientific, and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics – Limit and methods of measurement", the operating condition, especially, water load for microwave cooking appliances was described as following;

Microwave cooking appliances shall confirm to the limits of radiation in clause 5, when tested with all normal components such as shelves in place, and with water a load of 1 liter of tap water initially 20 °C ± 5 °C placed at the center of the load-carrying surface provided by the manufacturer. The water container shall be made of electrically non-conductive material such as glass or plastic (for example, the container defined in clause 8 of IEC 60705 may be used).

And, on IEC 60705 (1999), "Household microwave ovens – Methods for measuring performance", the specified water container was described as following;

A cylindrical container of borosilicate glass is used for the test. It has a maximum thickness of 3 mm, an external diameter of approximately 190 mm and a height of approximately 90 mm.

According to the related standard, it can be obscure the applying water container type to perform the radiation test. In this study, it has been analyzed radiated emission test results for vicinity spectrum of the fundamental frequency as a view of some different water container shape and has been suggested that the test condition should be clarified and the definite load container dimensions may also yield improvements in measurement uncertainty.

Microwave Oven as an ISM equipment

The microwave oven has a vacuum tube called "Magnetron", it injects microwave of 2,450 ± 50 MHz using ISM frequency.

The tolerance for ISM fundamental frequency is 2,450 ± 50 MHz. Fig. 1 shows a brief structure of microwave oven. Microwave generates from the antenna of magnetron, and than, it is guided to irradiate in the oven cavity using the waveguide.

This microwave is to heat the food (load) placed in the oven cavity. A portion is mostly absorbed by load and other portion is reflected by impedance mismatch between magnetron and load with cavity or mismatched transmission system impedance. So, impedance matching technology is very important to design the proper magnetron and microwave oven. The best design of microwave oven is to find and fulfill the matched condition. Therefore, microwave oven can efficiently operate by the matched condition.

In this time, the generated spectrum from magnetron is depended on the impedance of magnetron, waveguide, oven cavity and load. All properties except for load impedance are fixed or slightly changed during operation. On the other hand, load impedance is not fixed and changed according to the load conditions. The effects caused by mismatches, or standing waves, in the output transmission line of a magnetron are important both in practical application and in laboratory experiments.

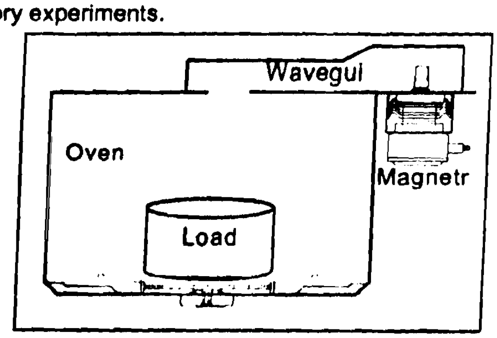


Fig. 1. Microwave oven structure

Magnetron and oscillation spectrum

A magnetron is a key component in microwave oven, which is microwave generator. A microwave magnetron may be naturally analyzed into three parts, which differ in function. These are the electron stream, the resonant system, and the output circuit. The electron stream, flowing in crossed magnetic and electric fields, interacts with that part of the field of the resonators which penetrates the interaction apace in such way that energy is continually abstracted from the electrons to appear as electromagnetic energy in the resonant system. The principle function of the resonant system is to serve as a frequency-determining element. It accomplishes this by storing the energy received from the electrons over a large number of cycles. It may be through of as a filter circuit with a narrow pass band, which allows only the frequency component in the electron stream and an external load. The properties of this transmission path are also arranged that the RF voltages, which the electron stream encounters, are suitable for efficient power transfer.

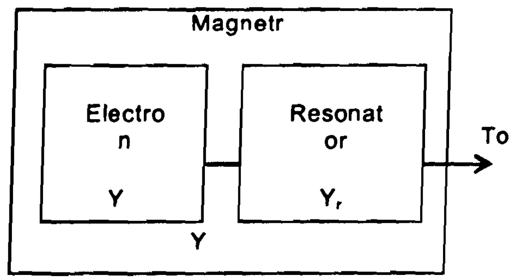


Fig. 2. Block diagram of a magnetron

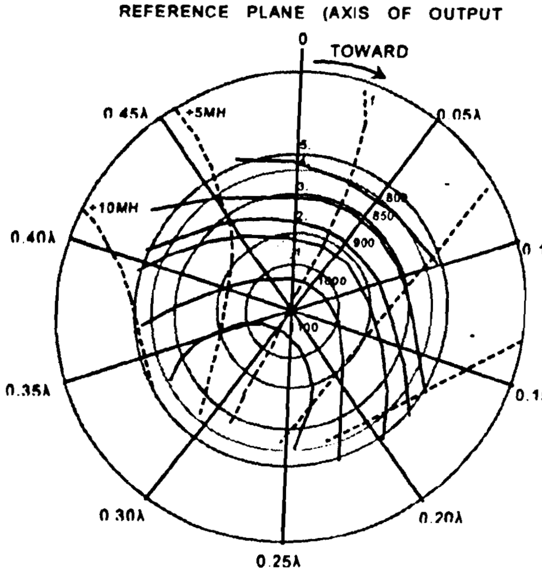
Microwave oscillation spectrum is found by setting the admittance looking out from a side resonator (the negative of the admittance looking in) equal to the admittance looking into the interaction space. That is, Ye + Tr = 0 at resonance, where Yr is the admittance of a side resonator.

Magnetron and oven cavity design for improving impedance

The design for new microwave oven cavity is the same meaning that the oven cavity impedance with waveguide should be matched the impedance guided from magnetron manufacturer using the designated and representative load(s).

As a point of view, the Rieke diagram is of great value in determining the effects of loading on the performance of a magnetron. And, Rieke diagram of a magnetron presents in the technical data is the one which is measured with a waveguide system to which the magnetron is connected through the specified coupler or launcher and with an oven cavity and load. The information that is needed in the preparation of a complete Rieke diagram is average current, voltage, output power, frequency, magnitude of standing wave, and phase of standing wave. That is, The Rieke diagram is a contour expression of equi-frequencies of a magnetron on a polar co-ordinate represented impedance (or admittance) chart. We can find or estimate some of the very useful information on microwave oven design by comparing the measured oven impedance with the magnetron Rieke diagram. They are such items as magnetron output power, magnetron oscillating frequency, stability of magnetron operation, output power of microwave oven, magnetron oscillation spectrum and spurious radiation, etc.

Fig. 3 indicates an example of Rieke diagram of a magnetron. This Rieke diagram should be always provided for the relevant test conditions and specifications from magnetron manufacturer. As it is, some input supply condition, load VSWR (σ_L), sink phase (l_0/λ_g) at specified VSWR, pulling figure (f_{pl}) at specified VSWR, and all output specifications.



Operating Conditions:

Power Supply Single Phase,
Full-Wave Rectifier Without Filter
Average Anode Current 330 mA
Waveguide: Standard Launcher in Fig. 3

——— Output Power (W)

- - - - - - Frequency (MHz)

Fig. 3. Example Rieke diagram of a magnetron

And, when the Rieke diagram is plotted, the used reference waveguide should be indicated and described all properties as shown in Fig. 4.

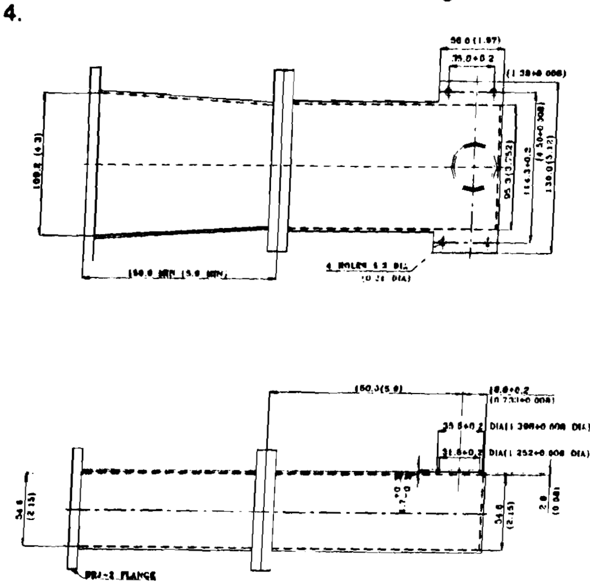


Fig. 4. Launcher and tapered waveguide for testing

Influence to oscillation frequency due to impedance change

The pulling figure of a magnetron is defined as the maximum change in frequency that occurs as a standing wave with a voltage ratio of 1.5 (It depends on the manufacturer's specification) is presented to the tube and the phase is varied 360°. Although the pulling may be determined from a Rieke diagram, this technique is needlessly laborious unless the other information contained in such a plot is desired.

Magnetron oscillating frequency changes according to the load impedance as shown in Fig.2 Rieke diagram, and this effect is called the pulling effect. The pulling of the operating magnetron may be defined as a maximum changes in frequency $f(\Gamma_p)$ of the system when the load reflection coefficient (Γ_L) is varied over all phases with $\Gamma_L = \Gamma_p$.

$$\text{VSWR} \quad \sigma_L = \frac{|V_{max}|}{|V_{min}|} = \frac{1+\Gamma_L}{1-\Gamma_L} \text{ ------------------------------(1)}$$

In this formula, if the load reflection coefficient $\Gamma_L = 0$, the circuit would be the matched condition that load VSWR σ_L=1.
For this load condition, it can be transmitted the microwave effectively from magnetron to food (load).
The employed load impedance is the impedance obtained when the load side (the other side of the coupler back wall) has been viewed from the antenna center of a standard coupler shown in Fig. 4 that is defined as the reference plane as shown in Fig. 5. In other words, note should be made of the aspect that Rieke diagram for the magnetron are expressed relative not to the impedance seen from inside the magnetron (interaction space), but strictly relative to the impedances seen from a given coupler antenna center toward the load side.
The equivalent circuit of a magnetron when a load has been connected is represented as shown in Fig. 5. Resonator admittance Y_m may be expressed by the equation below.

$$Y_m = g_m + j\left(\omega C - \frac{1}{\omega L}\right) \text{ ------------------------------(2)}$$

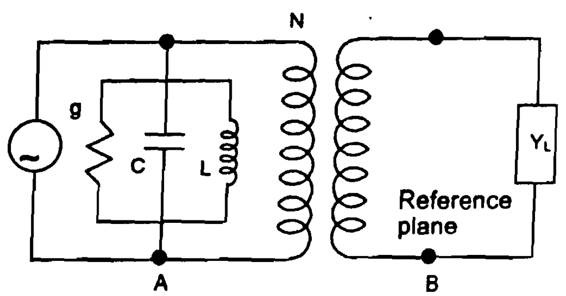


Fig. 5. Equivalent circuit of magnetron and load

Denoting the resonant frequency with f_0(Oscillating frequency for VSWR=1), equation(3) is transformed as follows due to $f_0 = 1/2\pi\sqrt{LC}$;

$$Y_m = g_m + j2\pi f_0 C\left(\frac{f}{f_0} - \frac{f_0}{f}\right) \text{ -------------(4)}$$

Load admittance Y_L is expressed by the equation below.

$$Y_L = \frac{1}{Z_L} = g_L + jb_L \text{ ---------------------------(5)}$$

Admittance Y_t of the total circuit is expressed by the equation below.

$$Y_t = Y_m + \frac{Y_L}{N^2}$$

$$= \left(g_m + \frac{g_L}{N^2}\right) + j\left\{2\pi f_0 C\left(\frac{f}{f_0} - \frac{f_0}{f}\right) + \frac{b_L}{N^2}\right\} \text{ --------(6)}$$

Because oscillating conditions of the magnetron call for a zero susceptance component of equation (6), we obtain;

$$2\pi f_0 C\left(\frac{f}{f_0} - \frac{f_0}{f}\right) + \frac{b_L}{N^2} = 0 \text{ ---------------------------(7)}$$

The ratio of power consumed in the load to that in the total circuit (circuit efficiency) is expressed by the equation below.

$$\eta_C = \frac{g_L/N^2}{g_m + g_L/N^2} \text{ ---------------------------(8)}$$

Equation (6) reveals that when load susceptance b_L is zero, $f = f_0$ will hold. When b_L takes on a positive value, f will be smaller than f_0. When b_L takes on negative, f will be greater than f_0.
Accordingly, it reveals that equ-frequency curves will coincide with equi-susceptance curves of the susceptance component. It is further revealed by equation (7) that the greater the load conductance, the greater will be the power.

Dynamic Impedance and Static Impedance

One of the most important measurements in evaluation microwave oven at the design stage in conjunction with magnetron operation is the input impedance measurement, as it gives important information concerning oven efficiency and magnetron stability, as well as acting as a guide to better heating uniformity, longer life and lower spurious generation.

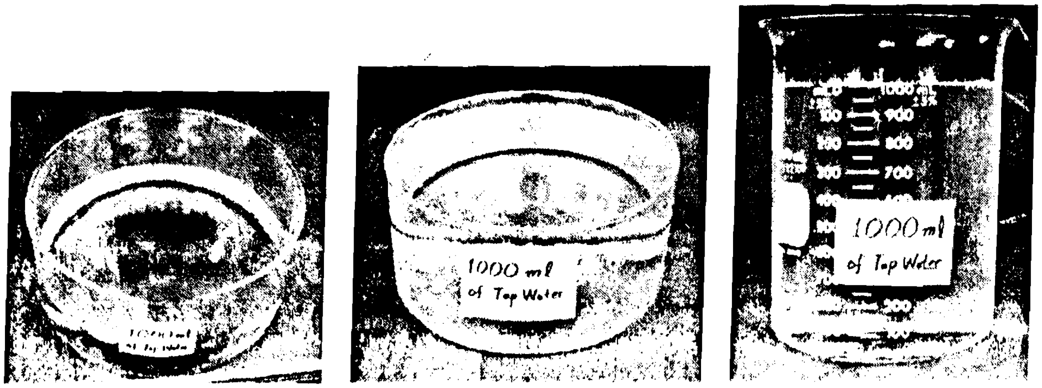
As a magnetron oscillation frequency changes from time to time due to the so called pulling effect of the load caused by actual oven impedance which the magnetron sees during the normal operation has to be found by looking for intersections of the Rieke diagram with a series of impedance data measured at different frequencies. In other words, magnetron load characteristic (Rieke diagram) intersects at only a few point of the static impedance data measured at several frequencies, how the magnetron is operating in the part where the Rieke diagram does not intersect such an impedance trace. However, it still seems that the application of the static impedance approach in practice is not as bad as one may expect from the discussion, and it is adequate and useful in most cases. The static impedance does not correctly represent the impedance of the actual oven cavity in the vicinity of the so called sink region where magnetron oscillation frequency changes widely for small changes of the load impedance.

In order to overcome the drawbacks of the static impedance measurements, it is necessary to use a signal source which adjusts its frequency by itself in relation to the load to which it is connected, according to the magnetron load characteristics. The dynamic impedance is that the incident and reflected waves are sampled along the waveguide between the magnetron and the oven cavity and it seems that this method is most practical for applying to most of the present oven designs. It is obvious that there is a great potential in the dynamic impedance measurement for evaluating microwave oven during design stage. Thus, the magnetron oscillating frequency or spectrum can be estimated at the same time, when adjusting it for better efficiency, better uniformity and better stability, only by checking dynamic impedance and comparing it with the Rieke diagram.

Radiated emission measurements with different size containers

To check effects of measurement results according to size of water load containers, three kinds of containers in size were used for radiated emission measurement of microwave oven. Three different size containers are shown in Fig. 6.

a. Type A : 3 mm in thick, 190 mm in outer diameter, and 90 mm in height
b. Tpye B : 3 mm in thick, 130 mm in outer diameter, and 100 mm in height
c. Type C : 3 mm in thick, 90 mm in outer diameter, and 160 mm in height



a. type A container container b. Type B container c. Type C

Fig. 6. Three cylindrical borosilicate glass containers used for radiated measurement

As the test results of microwave oven model "A", the fundamental ISM frequency spectrums (2,450 ± 50 MHz) shown in Fig. 7, 8 and 9 for each container were resulted in the different load impedance due to container shape and specifications and water quantity.
Below spectrums were varied wideness and shifted the frequency. These phenomena are caused by change of load impedance because of water load container specifications, even if water load quantity is the same.

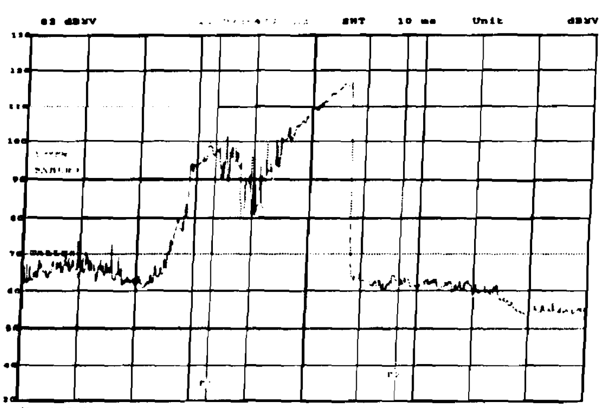


Fig. 7. Fundamental frequency and its side band spectrums
(Microwave Oven Model "A", 190 mm Dia. Container Used)

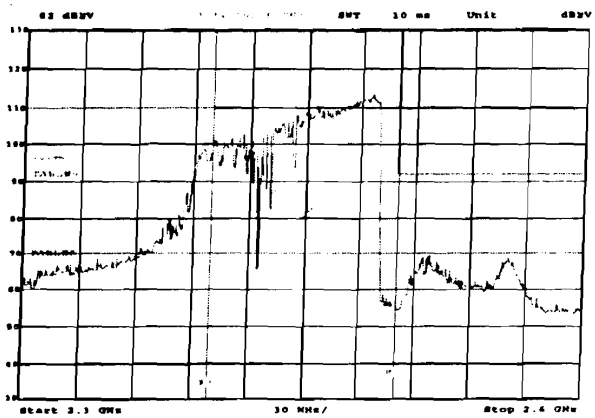


Fig. 8. Fundamental frequency and its side band spectrums
(Microwave Oven Model "A", 130 mm Dia. Container Used)

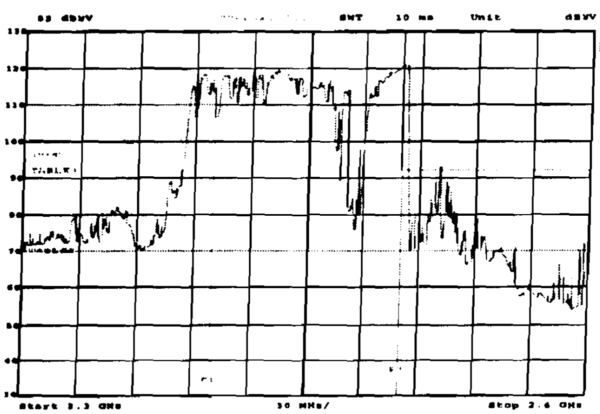


Fig. 9. Fundamental frequency and its side band spectrums
(Microwave Oven Model "A", 100 mm Dia. Container Used)

Comparison of the radiated emission test results for different size containers

Table 1 is to summarize the radiation test result which is frequency range 2.3 GHz to 2.6 GHz. For the data comparison, the radiated disturbance level using 190 mm and 130 mm diameter container with 1 liter water was complied with the CISPR 11 standard limit. But, its of 90 mm diameter container was non-compliance. The oscillation spectrum was also distinguished from other load containers and wider and more spread than its of 190mm diameter container.

So, the load container is very important factor for EMI performance of microwave oven. The impedance matching between output terminal of magnetron and oven cavity can be caused by container shape in addition to load quantity, dielectric constant, and etc.

Table 1. Radiated emission test results of side band frequency

Applied load container	Freq.	Measured Level	Limit	Margin	Result
	[GHz]	[dBuV/m]	[dBuV/m]	[dB]	
190mm Dia.	2.396	98.3	110	- 11.7	Pass
	2.505	63.6	92	- 28.4	Pass
130mm Dia.	2.396	98.5	110	- 11.5	Pass
	2.518	69	92	- 23	Pass
100mm Dia.	2.393	118.1	110	+ 8.1	Fail
	2.502	120.7	92	+ 28.7	Fail

Conclusion

The spectrum and disturbances of radiated emission is depended on impedance matching between the electron motion (active admittance Y_e) and load impedance (passive admittance Y_L). Total load impedance, which is passive component, consists of the magnetron resonator (anode), waveguide, oven cavity and actual load like food or water. Magnetron operates when $Y_e + Y_L = 0$. And, all admittance (or impedance) is a function of frequency and can be varied by load container shape. Consequently, oscillation spectrum and other EMI performance of microwave oven is related to impedance change and these impedance changes result from variation of load. So, the shape of load container is an important factor of microwave.

The container specification to design microwave oven as well as to evaluate EMI compliance should be specified.

1 REFERENCES

[1] CISPR 11 Edition 3.1 (1999), "Industrial scientific, and medical (ISM) radio-frequency equipment - Electromagnetic disturbance characteristics – Limit and methods of measurement

[2] IEC 335-1, "Safety of household and similar electrical appliances", Part 1: General requirements

[3] IEC 335-2-25 (2002), "Household and similar electrical appliances – Safety" Part 2-25: Particular requirements for microwave ovens, including combination microwave ovens

[4] IEC 60705 (1999), "Household microwave ovens – Methods for measuring performance"

[5] George B. Collins, "Microwave magnetrons", Copyright 1964, R&B Enterprises, West Conshohocken, PA.

[6] "Microwave Ovens", Copyright 1995,
LG Electronics Cooking Appliance Design Dept.